WHAT IS CLAIMED IS:

1. An optical waveguide having a working mode with a tailored dispersion profile, the waveguide comprising:

a dielectric confinement region surrounding a waveguide axis, the confinement region comprising a photonic crystal having at least one photonic bandgap, wherein during operation the confinement region guides EM radiation in a first range of frequencies to propagate along the waveguide axis;

a dielectric core region extending along the waveguide axis and surrounded by the confinement region about the waveguide axis, wherein the core supports at least one guided mode in the first frequency range; and

a dielectric dispersion tailoring region surrounded by the confinement region about the waveguide axis, wherein the dispersion tailoring region introduces one or more additional modes in the first range of frequencies that interact with the guided mode to produce the working mode.

2. The waveguide of claim 1, wherein the core has an average refractive index smaller than that of the highest index constituent of the dielectric confinement region.

3. The waveguide of claim 1, wherein the average refractive index of the core is less than 1.1.

4. The waveguide of claim 1, wherein the core comprises a gas.

5. The waveguide of claim 1, wherein the confinement region comprises at least two dielectric materials having different refractive indices.

6. The waveguide of claim 5, wherein the ratio of the refractive index of the higher index dielectric material to that of the lower index dielectric material is greater than 1.1.

7. The waveguide of claim 6, wherein the ratio of the refractive index of the higher index dielectric material to that of the lower index dielectric material is greater than 1.5.

8. The waveguide of claim 7, wherein the ratio of the refractive index of the higher index dielectric material to that of the lower index dielectric material is greater than 2.

9. The waveguide of claim 5, wherein the two dielectric materials in the confinement region form the photonic crystal.

10. The waveguide of claim 1, wherein the photonic bandgap is an omnidirectional photonic bandgap.

11. The waveguide of claim 1, wherein the photonic bandgap is sufficient to cause EM radiation that is incident on the confinement region from the core in the first frequency range and with any polarization to have a reflectivity for a planar geometry that is greater than 95% for angles of incidence ranging from 0° to at least 80°.

12. The waveguide of claim 1 wherein the photonic crystal is a two-dimensionally periodic photonic crystal.

13. The waveguide of claim 1 wherein the photonic crystal is a one-dimensionally periodic photonic crystal.

14. The waveguide of claim 5, wherein the confinement region comprises alternating layers of the two dielectric material surrounding the core about the waveguide axis.

15. The waveguide of claim 14, wherein the refractive indices and thicknesses of the alternating dielectric layers are sufficient to produce the photonic bandgap.

16. The waveguide of claim 15, wherein the photonic bandgap is an omnidirectional photonic bandgap.

17. The waveguide of claim 15, wherein the refractive indices and thicknesses of at least some of the alternating dielectric layers substantially satisfy the following equality:

$$\frac{d_{hi}}{d_{lo}} = \frac{\sqrt{n_{lo}^2 - 1}}{\sqrt{n_{hi}^2 - 1}}$$

where d_{hi} and d_{lo} are the thicknesses of adjacent higher-index and lower-index layers, respectively, and n_{hi} and n_{lo} are the refractive indices of the adjacent higher-index and lower-index layers, respectively.

18. The waveguide of claim 15, wherein the confinement region comprises at least 12 pairs of the alternating layers.

19. The waveguide of claim 15, wherein the confinement region comprises a sufficient number of pairs of alternating layers to limit radiative losses of the guided mode to less than 1 dB/m for a frequency in the first range of frequencies.

20. The waveguide of claim 15, wherein the confinement region comprises a sufficient number of pairs of alternating layers to limit radiative losses of the guided mode to less than 0.1 dB/km for a frequency in the first range of frequencies.

21. The waveguide of claim 1, wherein the first range of frequencies corresponds to wavelengths in the range of about 1.2 microns to 1.7 microns.

22. The waveguide of claim 1, wherein the first range of frequencies corresponds to wavelengths in the range of about 0.7 microns to 0.9 microns.

23. The waveguide of claim 1, wherein the ratio of the bandwidth of the first range of frequencies and a central frequency in the first range of frequencies is at least about 10%.

24. The waveguide of claim 1, wherein the waveguide axis is substantially straight.

25. The waveguide of claim 1, wherein the core has a circular cross-section.

26. The waveguide of claim 1, wherein the core has a hexagonal cross-section.

27. The waveguide of claim 1, wherein the core has a rectangular cross-section.

28. The waveguide of claim 1, wherein the variation in the effective index of the working mode is greater than 10% over the first range of frequencies.

29. The waveguide of claim 1, wherein the variation in the effective index of the working mode is greater than 50% over the first range of frequencies.

30. The waveguide of claim 1, wherein the variation in the effective index of the working mode is greater than 100% over the first range of frequencies.

31. The waveguide of claim 1, wherein the dielectric tailoring region is positioned between the core and the confinement region with respect to the waveguide axis.

32. The waveguide of claim 31, wherein the dispersion tailoring region comprises one or more dielectric layers surrounding the core about the waveguide axis that introduce the one or more additional modes.

33. The waveguide of claim 32, wherein the one or more dielectric layers that introduce the one or more additional modes are adjacent the core.

34. The waveguide of claim 32, wherein the dispersion tailoring region comprises at least one additional dielectric layer positioned between the core and the one or more dielectric layers that introduces the one or more additional modes.

35. The waveguide of claim 32, wherein the one or more dielectric layers that introduce the one or more additional modes are adjacent the confinement region.

36. The waveguide of claim 32, wherein the core defines a light line and wherein the interaction between the guided core mode and the one or more modes introduced by the dispersion tailoring region causes the working mode to cross over the light line for a subset of frequencies in the first range of frequencies.

37. The waveguide of claim 1, wherein the one or more modes introduced by the dispersion tailoring region correspond to one or more defect states in the photonic bandgap.

38. The waveguide of claim 32, wherein the one or more dielectric layers that introduce the one or more additional modes consists of only one dielectric layer.

39. The waveguide of claim 38, wherein the only one dielectric layers has a thickness that supports only one additional mode.

40. The waveguide of claim 38, wherein the only one dielectric layers has a thickness that supports multiple additional modes.

41. The waveguide of claim 1, wherein the dispersion tailoring region forms at least one defect in the photonic crystal to introduce the one or more additional modes into the first range of frequencies.

42. The waveguide of claim 31, wherein the confinement region and the dispersion tailoring region comprise alternating layers of two dielectric materials having different refractive indices surrounding the core about the waveguide axis.

43. The waveguide of claim 42, wherein the ratio of the refractive index of the higher index dielectric layer to that of the lower index dielectric layer is greater than 1.1.

44. The waveguide of claim 43, wherein the ratio of the refractive index of the higher index dielectric layer to that of the lower index dielectric layer is greater than 1.5.

45. The waveguide of claim 44, wherein the ratio of the refractive index of the higher index dielectric layer to that of the lower index dielectric layer is greater than 2.

46. The waveguide of claim 42, wherein the thickness of one or more of the layers in the dispersion tailoring region differs from that of a corresponding layer in the confinement region.

47. The waveguide of claim 42, wherein at least one layer in the dispersion tailoring region has a thickness that introduces a defect in the photonic crystal to support the one or more additional modes in the first range of frequencies.

48. The waveguide of claim 1, wherein the core has a substantially uniform refractive index.

49. The waveguide of claim 1, wherein the tailored dispersion profile comprises a frequency point of zero dispersion in the first range of frequencies.

50. The waveguide of claim 49, wherein the guided mode is a TE mode.

51. The waveguide of claim 49, wherein the first range of frequencies corresponds to wavelengths in the range of about 1.2 microns to 1.7 microns.

52. The waveguide of claim 49, wherein the first range of frequencies corresponds to wavelengths in the range of about 0.7 microns to 0.9 microns.

53. The waveguide of claim 1, wherein the dispersion tailoring region introduces multiple additional modes into the first range of frequency, and wherein the guided mode interacts with the multiple additional modes to produce multiple discontinuous working modes each having a tailored dispersion profile.

54. The waveguide of claim 53, wherein each of the working modes has a point of zero dispersion at a different frequency in the first range of frequency.

55. The waveguide of claim 53, wherein the first range of frequencies corresponds to wavelengths in the range of about 1.2 microns to 1.7 microns.

56. The waveguide of claim 53, wherein the first range of frequencies corresponds to wavelengths in the range of about 0.7 microns to 0.9 microns.

57. The waveguide of claim 1, wherein the tailored dispersion profile includes a first frequency point in the first range of frequencies having a dispersion D with an absolute value greater than 200 ps/(nm-km).

58. The waveguide of claim 57, wherein the tailored dispersion profile includes a first frequency point in the first range of frequencies having a dispersion D with an absolute value greater than 1,000 ps/(nm-km).

59. The waveguide of claim 58, wherein the tailored dispersion profile includes a first frequency point in the first range of frequencies having a dispersion D with an absolute value greater than 10,000 ps/(nm-km).

60. The waveguide of claim 57, wherein the sign of D is negative.

61. The waveguide of claim 57, wherein the sign of D is positive.

62. The waveguide of claim 57, wherein the relative dispersion slope at the first frequency point has an absolute value greater than about 0.02 nm^{-1}.

63. The waveguide of claim 62, wherein the relative dispersion slope at the first frequency point has an absolute value greater than about 0.1 nm^{-1}.

64. The waveguide of claim 57, wherein the tailored dispersion profile has a figure of merit at the first frequency point greater than about 200 ps/(nm-dB).

65. The waveguide of claim 64, wherein the tailored dispersion profile has a figure of merit at the first frequency point greater than about 500 ps/(nm-dB).

66. The waveguide of claim 57, wherein the first range of frequencies corresponds to wavelengths in the range of about 1.2 microns to 1.7 microns.

67. The waveguide of claim 57, wherein the first range of frequencies corresponds to wavelengths in the range of about 0.7 microns to 0.9 microns.

68. The waveguide of claim 57, wherein the guided mode is a TE mode.

69. The waveguide of claim 57, wherein the guided mode is an EH_{11} mode.

70. The waveguide of claim 57, wherein the guided mode is an HE_{11} mode.

71. The waveguide of claim 1, wherein the confinement region, core, and dispersion tailoring region comprise at least two axial segments having different cross-sectional refractive index profiles.

72. The waveguide of claim 71, wherein the cross-sectional profile of the two segments are substantially identical but for a scaling factor.

73. The waveguide of claim 71, wherein the scaling factor is greater than 1%.

74. The waveguide of claim 1, wherein at least a first end of the waveguide includes a coupling segment over which the refractive index cross-section is continuously varied to alter the field profile of the working mode.

75. The waveguide of claim 1 further comprising a second waveguide coupled to the first mentioned waveguide, wherein the cross-section of the second waveguide adjacent the first waveguide comprises regions of doped silicon located to improve coupling of the working mode into the second waveguide.

76. The waveguide of claim 1 further comprising a second waveguide coupled to the first mentioned waveguide, wherein the cross-section of the second waveguide adjacent the first waveguide comprises a hollow ring contacting the dispersion tailoring region of the first waveguide to thereby improve coupling of the working mode into the second waveguide.

77. An optical telecommunications system comprising:

a transmission waveguide for carrying at least a first optical signal; and

a dispersion compensating waveguide comprising the optical waveguide of claim 1, wherein the dispersion compensating waveguide is coupled to the transmission waveguide and has a tailored dispersion profile selected to compensate for dispersion imparted to the first optical signal by the transmission waveguide.

78. The system of claim 77, wherein during operation the transmission waveguide carries multiple optical signals each at corresponding frequencies, and wherein the tailored dispersion profile of the dispersion compensating waveguide is selected to compensate for dispersion imparted to each of the optical signals by the transmission waveguide.

79. The system of claim 77, wherein the dispersion compensating fiber is placed within the system where optical power is designed to reach at least 25 dBm.

80. A method for compensating for dispersion in an optical signal, the method comprising:

coupling the optical signal into a photonic crystal fiber having a tailored dispersion profile.

81. The method of claim 80, wherein the photonic crystal fiber comprises a confinement region including a one-dimensionally periodic photonic crystal.

82. The method of claim 80, wherein the photonic crystal fiber comprises a confinement region including a two-dimensionally periodic photonic crystal.

83. A method of designing a dispersion compensating fiber having a selected dispersion profile, the method comprising:

introducing a dispersion tailoring region to a waveguide design comprising a dielectric confinement region surrounding a waveguide axis that guides EM radiation in a first range of frequencies to propagate along the waveguide axis and a dielectric core region extending along the waveguide axis and surrounded by the confinement region about the waveguide axis, wherein the dielectric confinement region includes a photonic crystal structure having a photonic bandgap, and wherein the dielectric dispersion tailoring region is surrounded by the confinement region about the waveguide axis; and

selecting the refractive index profile of the dispersion tailoring region to introduce one or more modes in the first range of frequencies that interact with the guided mode to produce a working mode having the selected dispersion profile.

84. An optical waveguide having a working mode with a tailored dispersion profile, the waveguide comprising:

a dielectric confinement region surrounding a waveguide axis, wherein during operation the confinement region guides EM radiation in a first range of frequencies to propagate along the waveguide axis;

a dielectric core region extending along the waveguide axis and surrounded by the confinement region about the waveguide axis, wherein the core supports at least one guided mode in the first frequency range, and wherein the core has an average refractive index smaller than that of the dielectric confinement region; and

a dielectric dispersion tailoring region surrounded by the confinement region about the waveguide axis, wherein the dispersion tailoring region introduces one or more additional

modes in the first range of frequencies that interact with the guided mode to produce the working mode.

85. An optical waveguide comprising:

a dielectric confinement region surrounding a waveguide axis, the confinement region comprising a photonic crystal structure producing at least one photonic bandgap, wherein during operation the confinement region guides EM radiation in a first range of frequencies to propagate along the waveguide axis;

a dielectric core region extending along the waveguide axis and surrounded by the confinement region about the waveguide axis, wherein the core supports at least one guided mode in the first frequency range; and

a dielectric dispersion tailoring region surrounded by the confinement region about the waveguide axis, wherein the presence of the dispersion tailoring region causes the guided core mode to form a working mode that penetrates into the dispersion tailoring region for at lease one subset of frequencies within the first range of frequencies.

86. A photonic crystal optical waveguide comprising:

a dielectric core region extending along a waveguide axis;

a first set of at least three dielectric layers surrounding the core about the waveguide axis, the difference in refractive index between successive layers in the first set changing sign with each subsequent layer in the first set, and

at least one additional dielectric layer positioned between the core and the first set of layers, wherein the thickness of the additional dielectric layer differs from that of each of any three consecutive layers in the first set of layers by more than 10%.

87. The waveguide of claim 86, wherein the first set of layers guides EM radiation in a first range of frequencies to propagate along the waveguide axis.

88. The wavelength of claim 86, wherein the thickness of the additional dielectric layer differs from that of each of any three consecutive layers in the first set of layers by more than 30%.

89. The wavelength of claim 86, wherein the thickness of the additional dielectric layer differs from that of each of any three consecutive layers in the first set of layers by more than 150%.

90. A photonic crystal optical waveguide comprising:

a dielectric core region extending along a waveguide axis;

a plurality of higher index dielectric layers and a plurality of lower index dielectric layers alternating with one another to surround the core about the waveguide axis; and

at least one additional dielectric layer positioned between the core and the pluralities of alternating dielectric layers, wherein the thickness of the additional dielectric layer differs from that of each of any three consecutive layers in the pluralities of alternating dielectric layers by more than 10%.

91. The waveguide of claim 90, wherein the pluralities of alternating dielectric layers guide EM radiation in a first range of frequencies to propagate along the waveguide axis.

92. The wavelength of claim 90, wherein the thickness of the additional dielectric layer differs from that of each of any three consecutive layers in the pluralities of alternating dielectric layers by more than 30%.

93. The wavelength of claim 90, wherein the thickness of the additional dielectric layer differs from that of each of any three consecutive layers in the pluralities of alternating dielectric layers by more than 150%.

94. An optical waveguide comprising:

a dielectric confinement region surrounding a waveguide axis, wherein during operation the confinement region guides EM radiation in a first range of frequencies to propagate along the waveguide axis;

a dielectric core region extending along the waveguide axis and surrounded by the confinement region about the waveguide axis, wherein the core has an average refractive

index smaller than that of the dielectric confinement region, defines a light line, and supports at least one guided mode in the first frequency range; and

a dielectric dispersion tailoring region surrounded by the confinement region about the waveguide axis, wherein the presence of the dispersion tailoring region introduces causes the guided mode to form a working mode that crosses over the light line.

95. An optical waveguide comprising:

a dielectric confinement region surrounding a waveguide axis, wherein during operation the confinement region guides EM radiation in a first range of frequencies to propagate along the waveguide axis;

a dielectric core region extending along the waveguide axis and surrounded by the confinement region about the waveguide axis, wherein the core supports at least one guided mode in the first frequency range; and

a dielectric dispersion tailoring region surrounded by the confinement region about the waveguide axis, wherein the presence of the dispersion tailoring region causes the guided core mode to form multiple discontinuous working modes each of which penetrates into the dispersion tailoring region for a different subset of frequencies within the first range of frequencies.